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Published in:
Antennas and Propagation Society International Symposium

Link to article, DOI:
[10.1109/APS.1989.135053](https://doi.org/10.1109/APS.1989.135053)

Publication date:
1989

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Brown, K. (1989). The current distribution on the feeding probe in an air filled rectangular microstrip antenna. In *Antennas and Propagation Society International Symposium* (Vol. Volume 3, pp. 1680-1683). IEEE.
<https://doi.org/10.1109/APS.1989.135053>

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THE CURRENT DISTRIBUTION ON THE FEEDING PROBE
IN AN AIR FILLED RECTANGULAR MICROSTRIP ANTENNA

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INTRODUCTION. Several authors have used an integral equation formulation when calculating the impedance of a probe fed microstrip patch antenna [1,2,3]. They all assume that the current distribution on the probe is uniform which restricts the application to electrically thin microstrip antennas. In this paper, the current distribution on the probe, and the input impedance of the rectangular air filled microstrip antenna, will be calculated using the electrical field integral equation (EFIE) formulation. An rigorous model for the coaxial line excitation is adopted [4, pp. 35-44], which makes the formulation valid for electrically thick microstrip antennas. The EFIE is solved numerically using the moment method with a piecewise linear approximation of the patch current and a polynomial approximation of the probe current. The reader is referred to [5] for further details of the EFIE-formulation.

RESULTS. The probe fed rectangular air filled microstrip antenna is shown in fig. 1. Throughout this analysis, the following dimensions of the microstrip antenna are used

$$\begin{array}{ll} L = 75 \text{ mm} & W = 37.5 \text{ mm} \\ L_p = 18.75 \text{ mm} & W_p = 18.75 \text{ mm} \end{array}$$

The inner and outer radii of the coax cable are $a = 0.65 \text{ mm}$ and $b = 2.1 \text{ mm}$, respectively.

In fig. 2 the calculated input impedances are shown for four different values of the microstrip antenna height h . It is observed that the location of the maximum of the real part decreases in frequency as h is increased, and the minimum value of these maxima is found at $h = 12 \text{ mm}$. The imaginary part exhibits an increasing inductive shift as h is increased.

The resonant frequency of the rectangular microstrip antenna is defined as that frequency where the power contained in the x- or y-component of the patch current is a maximum. In fig. 3, the probe current is shown for the first microstrip patch resonance in the x-direction. We observe that the amplitude of the probe current is nearly constant for $h \leq 12 \text{ mm}$, while the phase changes -24° for $h = 6 \text{ mm}$ and -28° for $h = 12 \text{ mm}$ as we move along the probe. From this it may be concluded that integral equation formulations based on the uniform probe current assumption breaks down because the phase of the probe current varies along the probe.

In fig. 2, the real part of the impedance for $h = 24 \text{ mm}$ indicates a second maximum located above $f = 2 \text{ GHz}$. To investigate this further the input impedance was calculated for $h = 27, 30, 33$ and 36 mm , and the results are shown in fig. 4. The first microstrip patch resonant frequency was for all four heights found to be $1.55 \text{ GHz} \pm 0.0125 \text{ GHz}$ (the impedance was calculated with a frequency step of 12.5 MHz).

In fig. 4, we observe two closely located maxima of the real part of the input impedance. A minimum distance between the two maxima is observed for $h = 30 \text{ mm}$. This behavior may be explained if we recognize that beside the first resonant frequency of

the microstrip patch ($f = 1.55$ GHz), there will be another resonance originating from the probe with the patch acting as a capacitive hat.

It was found by numerous calculations that operating the microstrip antenna at the resonant frequency of the microstrip patch gives the best results with respect to the side lobe level and cross polar level.

To validate the calculations presented in this paper, the impedance of the rectangular air filled microstrip antenna was measured for the case $h = 6$ mm and was found to agree with the calculated impedance (fig. 5).

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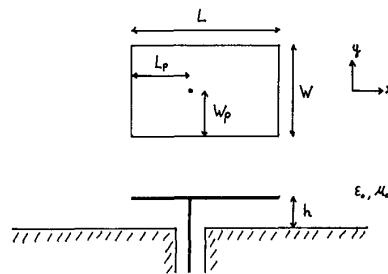


Fig. 1 Probe fed rectangular air filled microstrip antenna.

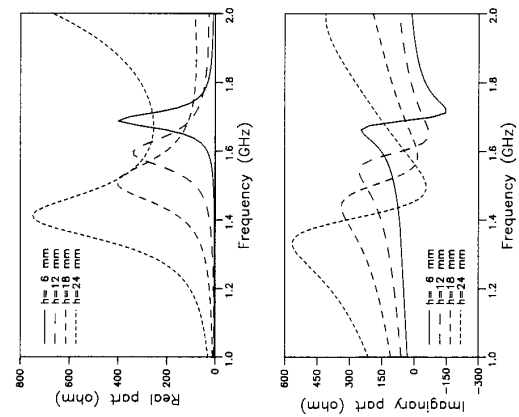


Fig. 2 Calculated input impedance.

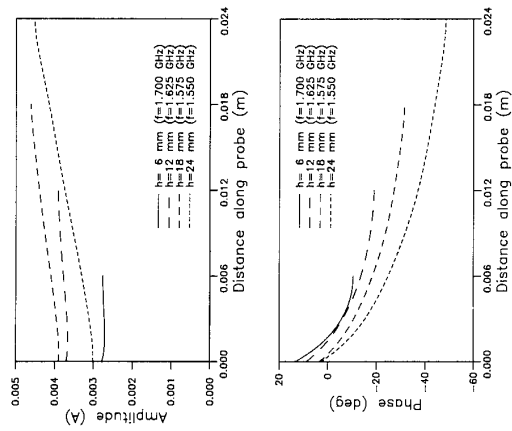


Fig. 3 Current along probe.

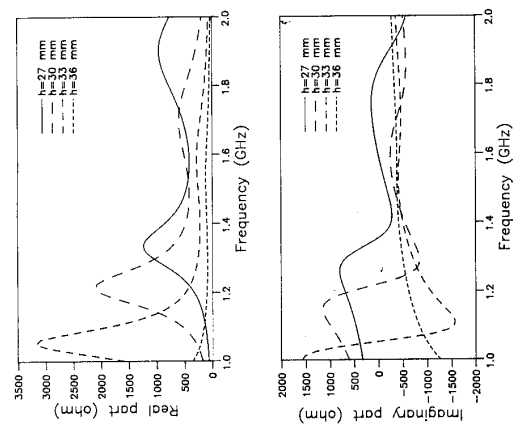


Fig. 4. Calculated input impedance.

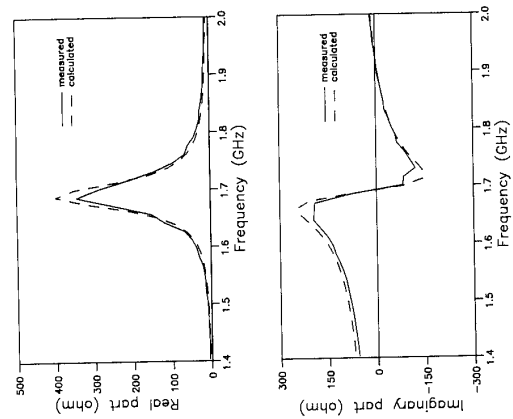


Fig. 5. Calculated and measured input impedances. $h = 6$ mm.